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The Control of Diseases and Insects of Tobacco

JAMES JOHNSON

A TYPICAL FIELD OF WISCONSIN TOBACCO

The production of a good yield of sound tobacco depends in a large measure upon controlling the diseases and insects affecting the crop.

AGRICULTURAL EXPERIMENT STATION

OF THE UNIVERSITY OF WISCONSIN

MADISON, WISCONSIN

DIGEST

The tobacco plant and its product is attacked by a number of diseases and insects which causes a large annual loss to Wisconsin tobacco growers and packers. A knowledge of the cause of the diseases and the life histories of the insects, together with predisposing factors, will enable the growers and packers in a large measure to control these pests. Pages 3–4

The steaming of the soil for tobacco plant beds by the inverted pan method has proven to be the most satisfactory way of preventing the bed-rot and root-rot diseases of the seedlings. In addition this method kills the weed seeds and produces a greater number of early, uniform and healthy plants for transplanting. Pages 7–10

The amount of bed-rot in tobacco can, however, be reduced considerably by proper selection of soil for the seed bed and by proper thickness of sowing the seed, followed by judicious watering and ventilation. Pages 11–13

The root-rot of tobacco is one of the most serious diseases of tobacco in the seed bed and in the field. It is characterized by the decay and loss of the root system, resulting in a stunting of the plants. Complete control of the disease is difficult. Sterilizing the seed beds and planting on new soils is recommended. Pages 13–14

The cause of the various rusts of tobacco is not yet accurately known and satisfactory methods of control have not been worked out. Pages 15–16

The diseases of curing tobacco are best controlled by regular attention to proper ventilation. Growing an early crop, proper construction of the sheds, and good judgment in hanging are essential points. When the shed diseases occur, artificial heat should be resorted to in order to prevent further spread of the diseases. Pages 18–23

The troubles of the packer, i. e., black-rot and must, are due to fungous development aided by excessive moisture at the time of packing, together with favorable temperatures for fungous growth. Control of these diseases lies largely in regulating the per cent of moisture at the time of packing and in controlling the temperatures of fermentation. Bulk sweating is one of the best means known to reduce damage in sweating tobacco. Pages 23–27

The principal insects affecting the tobacco plant are the cut-worms, horn or tobacco-worms, and the grasshoppers. Late fall plowing is one of the most simple means for reducing the numbers of cut-worms and tobacco-worms especially. Pages 27–28

The use of poison baits for cut-worms, and spraying for tobacco-worms in seasons when they are very destructive, are practices which should be given a good trial by Wisconsin tobacco growers. Pages 29–31

The Control of Diseases and Insects of Tobacco

JAMES JOHNSON

DISEASES OF TOBACCO[1]

Tobacco growers are familiar with a number of diseases which tend to reduce the profits of the crop. The loss varies greatly from year to year, depending largely upon weather conditions. The estimated total loss to this state alone frequently runs into the hundreds of thousands of dollars. Much of this loss might be prevented if the producer would use intelligent precautions to combat these diseases. The tobacco plant and its product is subjected to a great variety of unnatural conditions before it reaches the manufacturing stage, predisposing it to attack from diseases. It is consequently affected by a series of pests from time of sowing the seed until it is manufactured into a finished product. By a critical study of the causes of these various maladies and the conditions which influence their development, it is possible to obtain several suggestions as to methods of controlling them. Some of these suggestions require experimental proof before they can be recommended for practice, and as far as possible this proof is being obtained. Others are so self-evident that experimental proof, although highly desirable, is not necessarily required before recommendations are made. The determination of the actual cause of a disease is a most important factor in its relation to remedial measures. A knowledge of these causes, together with the secondary factors which aid in the development of disease is essential to an intelligent system of combatting them. This bulletin is intended to put before the

[1] The writer wishes to express his thanks to L. R. Jones, Plant Pathologist, and J. G. Moore, Horticulturist, for suggestions in preparing this manuscript for publication.

practical grower the causes and remedial measures for these diseases as far as is known at the present time. The various diseases are taken up as far as practicable in the order in which they occur during the culture of the crop.

The term "plant disease" may be made to include in the broadest sense any abnormal or unhealthy condition of plants. In this sense insect, mechanical and frost injuries, improper nutrition, physiological disturbances, and bacterial and fungous parasitism would be included. In a narrow sense, however, disease in plants may be considered to include only those abnormal conditions which arise from a cause existing within the tissues of the plant itself. It is in this latter sense that we will use the term in this bulletin. Plant diseases will then include only abnormal conditions brought about by bacterial and fungus parasitism, or by physiological disturbances. Strictly speaking, diseases only refer to an abnormality of plants when in a living condition. In treating the subject of tobacco diseases as a whole in this bulletin from the practical standpoint it is made to include also injuries to the crop which occur during and following curing.

THE NATURE OF PLANT DISEASES

Plant diseases may be divided into two classes,—(1) *parasitic* and (2), *non-parasitic*. Parasitic diseases are those caused by bacteria or fungi living upon and deriving their nourishment from the living plant which is known as the host. Non-parasitic diseases (sometimes called physiological) are those in which there is no living organism concerned, but are due rather to an internal disturbance of the functions within the plant itself. As an example of a parasitic disease of tobacco we may cite "bed rot" which is caused by a fungus. A good example of a non-parasitic disease is the "mosaic" disease or "calico" of tobacco.

Bacteria and fungi are among the lowest forms of plant life. They are different from our ordinary plants in that they lack the green coloring matter, chlorophyll, which enables plants to manufacture their own food from the elements of the soil, water and air. Bacteria and fungi must therefore feed upon the living or dead tissues of other plants or animals. Those which feed upon living tissues are called parasites. The fungi or bacteria which feed upon dead tissues are called saprophytes. Some of the fungi which cause diseases in tobacco, as stem rot and black rot, are saprophytes.

These disease producing organisms are practically invisible to the naked eye. Under a microscope the fungi are found to consist largely of minute threads; a number of these threads together are known as the mycelium of the fungus. This mycelium corresponds to the roots of higher plants and runs in and between the cells of the affected tissue, absorbing food and destroying the tissue. Fungi reproduce by means of spores which serve the same purpose as seeds in higher plants. They are more simple in structure than seeds, and are produced in much greater numbers besides being so light that they are readily scattered by the wind. Spores germinate by sending out a germ tube which enters the host tissue and develops a new mycelium. The spores can germinate and the mycelium grow only within certain ranges of temperature, and in the presence of proper amounts of moisture, food and air. It is possible frequently to check the development of disease by controlling the temperature and humidity of the atmosphere surrounding the affected tissues. A more efficient means of controlling disease is to kill the disease-producing organism either by heat or chemicals. This method can only rarely be resorted to on account of the danger to the host tissue, or because of expense of application. It is with these principles in mind, however, that the tobacco producers must look forward to reducing the losses due to disease.

BED ROT OR DAMPING OFF

The rotting of young plants in a plant bed is usually spoken of as bed rot or damping-off. This disease is caused by fungi[1] which live in and upon the young stems of the plant. The disease practically always starts just at or near the surface of the ground due to the more favorable moisture conditions at this point. Once inside the stem the disease may spread further up the stem and sometimes into the young leaves, causing their decay. As a result the stems become weak and the plant is said to become "top-heavy" which causes it to bend over and finally wilt. The disease may also attack the plants when they are very small in which case none of these physical effects are conspicuous, and the only result noted is a yellowing and dying out of the young plants, leaving an uneven or thin stand. The disease, in fact, has been

[1] The damping off of tobacco in Wisconsin is due to two species of fungi, *Pythium debaryanum* and Rhizoctonia. Wis. Research Bul. 31.

frequently observed to kill out a seeding before the plants come out of the ground, and it is possible that much of the so-called "poor seed" or "freezing out" is due to the damping-off fungus.

The damping-off fungi are present in practically all of the garden soils of the country. It is therefore not an absolute as-

FIGURE 1.—TOBACCO PLANTS AFFECTED WITH BED ROT

This disease frequently causes the loss of large areas of plants in tobacco beds. Steaming the soil, or attention to selecting the soil for the plant beds, and proper thickness of sowing the seed are recommended to control this disease.

surance against the disease to select new soil for the seed beds. However, it is always advisable to sow on new soil in preference to sowing in soil where the disease has previously occurred. Fortunately, these fungi produce relatively few spores and these are not spread as promiscuously by the wind as in the case of many other common fungi. For this reason the disease is more likely

to occur only in isolated spots, and it becomes possible to destroy the fungi in small areas without much danger of reinfection. The remedial measures against damping off may be classified under three heads, i. e., preventive methods, cultural methods and checking methods.

Control Measures for Bed Rot

The preventive methods are the sterilization of the soil by heat, (either by means of steaming, roasting, or surface firing,) or by means of the formalin soil drench. By prevention is here meant a measure which must be applied before the sowing of the seed, and which if properly applied will absolutely control the disease. After several years of trial at this station the steaming process has been found to be the most successful.

Steaming Soils—Several methods have been used for applying steam to the soil for sterilization purposes. Of these the one which lends itself best to outdoor conditions and which has been found most successful for tobacco growers is known as the "inverted pan" method. To steam the soil by this method a boiler, pan, and connecting steam hose or pipe is required. The boiler must have a considerable capacity and be capable of holding a high pressure in order to do the work quickly and thoroughly. For general purposes the ordinary traction engine has been found best, since it can usually be obtained in nearly all tobacco growing communities of this state. The steam may be taken out of the steam dome by removing the whistle and attaching a three-fourths inch pipe. This pipe can be reduced to one-half inch if desired, to fit the hose. A steam valve should be placed near the boiler for a shut-off. The steam is carried to the pan preferably through a three-fourths inch four ply steam hose. For ordinary purposes the hose should be about twenty feet in length. The substitution of pipe for part of the hose will lessen the cost somewhat, but will not be as convenient.

The pan used for steaming is made of No. 16 galvanized iron. The size and shape can be made to vary as preferred and is limited largely by the capacity of the boiler and the weight of the pan. The pan found best suited for tobacco bed steaming is made six feet wide, twelve feet long, and eight inches deep. Handles of one-inch gas pipe are attached to the sides, preferably with "street" or threaded elbows and flanges. The iron must be riv-

eted and soldered together so as to be air tight. The lower edge of the pan should be fairly sharp in order that it may be readily pressed into the soil. The top of the pan is preferably reinforced by two strips of angle iron running the full length of the pan. A one-half to one inch pipe, firmly attached at one end of the pan with a union connection to which the hose is attached, serves as the inlet for the steam. It also appears advisable to make the steam discharge into the pan through a short piece of perforated

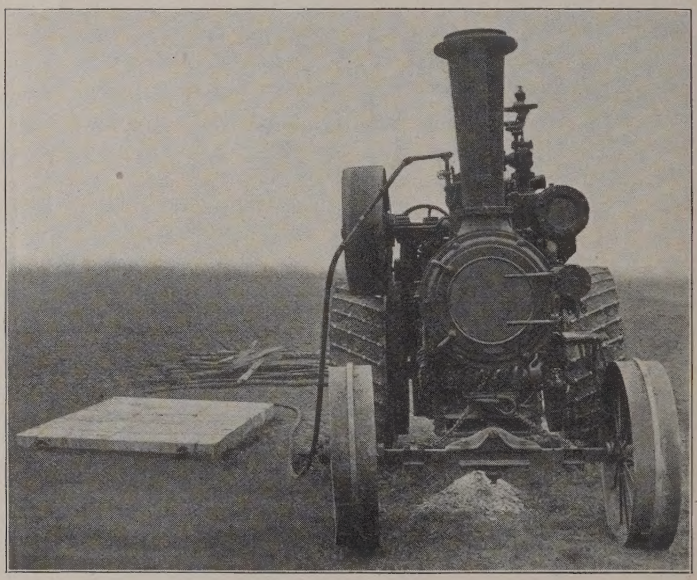

FIGURE 2.—STEAMING SOIL FOR TOBACCO BEDS

To steam soil by the inverted pan method a boiler, pan, and steam hose or pipe connections are required. Steam traction engines, which are obtainable in almost every tobacco growing community of Wisconsin, are desirable for this purpose.

pipe to serve as a distributer, in preference to a straight discharge from the inlet pipe. The general adoption of the use of this steaming process will no doubt result in improvements in the construction of the pan.

The steaming of the soil is done in the spring sometime before sowing the seed. This may vary from two to three weeks before sowing to the day preceding the sowing of the seed. The essential points are that the soil should first be cooled off and that no unsteamed refuse or soil be raked into the steamed por-

tions since this may introduce weed seeds and diseases. For this reason it is advisable to put the frames and canvas on the beds soon after the steaming is done. As the plants grow faster on steamed soil the sowing may ordinarily be made ten to twelve days later than usual.

The soil should be made ready for the seeding before the steam pan is set upon the bed. The edges of the pan are pressed down into the soil an inch or two in order to prevent the steam from escaping from under the pan.

The steam should be turned into the pan from the boiler at a pressure of 100 to 150 pounds for thirty minutes. The amount of steam allowed to enter must be regulated somewhat by means of the valve at the dome. If the steam is run in too fast, the pan is liable to be lifted and steam allowed to escape. After thirty minutes the steam may be shut off and the pan moved to the next section where the operation is repeated. The work could be done more quickly and cheaply with two pans. The steam could then be turned into one pan for twenty minutes and the pan allowed to remain over the soil for ten minutes more to conserve the heat while steam is being run into the second pan. Although it has been found that thirty minutes steaming gives the best and most economical results for most soils, the length of time for steaming will vary somewhat with the character of the soil and the pressure of steam used. In general the heavier the soil, or the lower the pressure, the greater the length of time required for steaming. For best results the soil should be moist and not dry or wet when steamed.

The immediate results of steaming are that for the first few days the soil dries on the surface more rapidly than does unsteamed soil. This is a slight disadvantage, but is readily overcome by one or two additional light applications of water. The plants also grow slower in steamed soil the first week or two, but this effect rapidly disappears in the remarkable increased growth of the plants which follows later when transplanted into ordinary soils. The benefits of steaming are briefly as follows:

1. Bed-rot and root-rot diseases are prevented from developing in the plant beds.
2. Weed seeds are killed.
3. Earlier plants are produced.
4. More uniform and vigorous plants are grown.
5. More plants per square foot are produced.
6. Some of the insect pests of the seed bed are killed.

These results of soil steaming make it a practical operation for tobacco growers where the boilers are at hand or can be rented. The cost of steaming can be much reduced by neighboring farmers cooperating in the purchase or renting of materials required. A still more satisfactory method is for the owner of a traction engine to provide himself with the pans and to steam the beds in the neighborhood at a certain price per rod. This undoubtedly could be done with profit to both parties concerned. The cost of steaming under the co-operative method will be approximately seventy-five cents per 100 square feet. The cost should not under any ordinary conditions exceed one dollar per 100 square feet. In many cases the cost of hand weeding for a like area exceeds this amount.

The condition of the country roads in the spring may offer an obstacle to the moving of traction engines, but this is not likely to occur sufficiently often to prevent the general adoption of this valuable method by the tobacco growers of this state.

The roasting process requires that the soil be shoveled on to a large iron pan beneath which a fire is maintained. Care should be taken not to allow the soil to burn as that destroys its physical character. The time of roasting must be left largely to the judgment of the operator. One hour will usually be found sufficient for each roasting. The seed bed soil to a depth of four inches must be roasted for best results. Tobacco bed "furnaces" can be purchased on the market for this purpose. This method is not recommended for tobacco growers in Wisconsin who are in position to steam their seed beds.

Surface firing consists in burning any material over the soil where the seed beds are to be located. Brush is frequently used. It is preferable to have the fire raised a few inches from the ground by laying some old rails or large branches on the seed bed first, before piling on the smaller material. This will aid in allowing the heat to come in contact with the soil more readily. A heating of from 45 minutes to one hour is usually sufficient to kill any living organism in the first three or four inches of the soil. The disadvantages of this method are the difficulty of obtaining burnable material in some places and the injury done to the mechanical condition of some soils.

Formalin Treatment. Various strengths of formalin drenches have been recommended by different authors for the control of bed rot. A series of experiments which have been carried on

at the Wisconsin Experiment Station have shown that formalin at the strength usually recommended (1–100) is not sufficient to entirely prevent the disease, but that this can be done with a strength of 1–50 formalin. The method of applying this treatment is as follows:—The soil should be first prepared so as to be practically fit for seeding. One gallon of formalin (40 per cent formaldehyde) is added to 50 gallons of water (1 barrel), and thoroughly stirred. This solution is applied at the rate of 50 gallons per rod 6 feet in width, (two quarts per square foot) or a little heavier, depending somewhat upon the readiness with which the soil takes up the solution. Most soils will require that this amount of water be applied gradually before being taken up The soil should then be covered with some material, such as old blankets, carpets or bags, to hold the formalin fumes in the soil for a

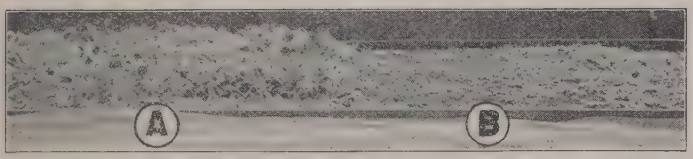

FIGURE 3.—PLANTS THRIVE BEST ON STEAMED SOIL

(A) Steamed. (B) Unsteamed, with weeds removed. This system furnishes the best solution for growing good tobacco plants.

couple of days. A similar method and quite as effective would be to stretch the plant bed canvas over the boards as is done after seeding. The soil should be given at least six to eight days to dry out after treatment before seeding, as the seed will not germinate in the presence of the formaldehyde gas. The time required for the beds to dry out is the main disadvantage of the formalin drench. The application of the formalin drench in the late fall would probably be advisable in some cases.

Formalin can be purchased in quantity at 12 to 15 cents per pound. The cost of application will hence be approximately one dollar per rod of seed bed six feet in width. This cost is almost prohibitive to tobacco growers unless plants cannot be satisfactorily grown without such treatment. Although the cost of steaming the seed beds is approximately the same, the numerous other beneficial effects of this method greatly offset the original cost.

Cultural Methods. Much can be done towards the reduction of the amount of damping-off in tobacco plant beds by close ob-

servance of simple rules of culture. One of the greatest, if not the greatest mistake, made by tobacco growers in the management of their seed beds is that of sowing the seed too thick. Ordinarily two or three ounces of seed are sown where one would give better results. That crowding of plants renders them especially susceptible to disease has been experimentally shown to be in direct proportion to the thickness of sowing the seed. One ounce of seed with a germinating capacity of 80 to 90 per cent will sow five to six rods of a bed six feet in width.

FIGURE 4.—TOBACCO SEEDLINGS AFFECTED WITH ROOT ROT

(A) Healthy roots. (B and C) Diseased roots. Sterilizing the soil by heat or formalin solution will control this disease in the seed bed.

In soils where damping-off has occurred to an injurious extent the previous season, the soil contains considerable more of the mycelium and spores of the disease producing fungi. When such soil is again sown to tobacco there is a much greater likelihood of the plants damping-off than if sown on comparatively new soils. For this reason old infected seed beds should be avoided. Damping-off occurs only in the presence of an excess of moisture above that required for plant growth. It is especially likely to be more injurious in seed beds where water stands for a considerable time before draining away. For this reason only the best drained soils should be used for seed beds. It has also been demonstrated that the disease spreads most rapidly in soils containing much decaying vegetable matter. On many soils it is preferable to apply the

manure in the fall, allowing the fertilizing elements to leach into the soil, and to take off most of the coarse manure before working the soil up in the spring in preparation for seeding.

Checking the Disease. The most urgent calls for means of preventing damping-off come at a time when the plants are dying off rapidly in the plant beds. It is very difficult to check the disease at this time owing to the weather conditions which usually prevail. High temperature, excessive soil moisture, and humidity of the atmosphere are all favorable to the disease. A large number of materials for spraying the plants and soil at this time have been tried but with no results. The only check that can be applied at this time is removing the covers from the beds so as to lower the temperature and dry the plants and soil off as soon as possible. The insufficiency of this treatment during long periods of warm rainy weather emphasizes the importance of using preventive and cultural measures before sowing the seed.

Root Rot or Black Root

The tobacco root rot is a fungus disease[1] attacking the roots of tobacco in the seed bed and field causing the young roots to turn brown or black and decay and the older roots to become scabby in appearance which results in the partial starvation and consequent stunting or death of the plant. Plants attacked by this disease have all the appearance of suffering from drought or malnutrition. The disease is, however, favored by a high per cent of moisture in the soil. In many cases the plants may stand all summer in the field without making any apparent growth, resulting sometimes in practically a total loss to the grower. From this condition gradations occur up to an unnoticeable amount of damage. The writer believes that this disease is the cause of the so-called "running out" of tobacco soils in a large number of cases rather than the assumed depletion of fertility of land repeatedly planted to tobacco.

This disease undoubtedly has existed in Wisconsin for a number of years, but it is only recently that its importance as affecting the general condition of the tobacco crop has been understood.

Root-rot may occur in the plant beds or in the field. If diseased plants from the beds are set in the field, the disease is practically

[1] The botanical name of the root rot fungus is *Thielavia basicola*, Zopf.

certain to continue to a greater or less extent, depending upon the amount of moisture in the soil. If healthy plants are set in a diseased field, the result is practically the same, although the newly set plants start out better and may mature a larger crop. The only positive means known at present of avoiding the disease is to transplant only healthy plants in healthy soil. New land should therefore be used whenever possible as a means of control. However, the time will not be far distant when all of the best tobacco soils will be diseased more or less and other means for checking this disease must be established. The sterili-

FIGURE 5.—AN UNEVEN STAND AS A RESULT OF ROOT ROT

The large, nearly normal plants in some diseased fields are apparently resistant to the disease, and suggests the possibility of developing disease resistant strains.

zation of the soil by steam or formalin as recommended for the control of bed-rot will also prevent the development of root-rot in the beds. This is the first important step a grower should take towards avoiding this disease, but it will not always prevent it, as infection may take place in the field.

It is a common occurrence in fields badly diseased with root-rot to see a striking unevenness in the growth of the plants. Some plants may appear practically normal while neighboring plants are too small to be harvested. This suggests the possibility of producing disease-resistant strains of tobacco, which will be able to produce a good crop in the worst infected fields. Favorable results have already been secured along this line. Future control of this troublesome disease will undoubtedly be brought about in this manner.

THE BROWN AND WHITE RUSTS

A common field disease of tobacco in Wisconsin and one which has given the growers some concern is the so-called "rust." The disease is characterized by the death of small, usually circular spots in the leaves of maturing tobacco. In bad cases these rust spots may run together, causing large portions of the leaf to dry and shrivel up. Close examination of these spots show them to be made up of concentric rings which suggest a gradual spread of the disease from a central point. The trouble usually occurs when the plants are from three-fourths to full grown and apparently more generally on the bottom leaves following a wet season, and especially on low land. This, however, is not always the case. Brown rust has been observed on the top leaves in dry seasons, and on light well drained soils which tend to disprove the relation of excessive moisture to the disease. Close observation of this disease, together with some experimental work has yielded little advance in determining the true nature of the trouble. The writer is inclined to place this disease among the physiological disturbances of the plant as no parasite has been found in Wisconsin associated with the rust spots. The appearance of this disease has been attributed to a number of different conditions which are ordinarily unfavorable to plant growth. Some of these acting singly or in conjunction with others are undoubtedly influential in bringing about this trouble, but do not satisfactorily explain it. The following are some of the most important theories as to the cause of this disease. Rust is due to:

1. A fungus[1] or bacterial development upon the leaf following a moist season.
2. An excess of certain fertilizers in the soil.
3. Insufficient moisture while the plant is in vigorous growth, causing the leaf to perish in spots from lack of food.
4. The use of too much heating manure followed by a period of dry weather.
5. Excessive moisture in the soil causing roots to rot, followed by partial starvation of the plant.
6. Deep cultivation cutting the roots and a consequent interference with the feeding processes.
7. Over-ripeness of the plant.

[1] Rust spots have been shown to be due to certain parasitic fungi in other tobacco sections.

8. Moist weather succeeded by very hot weather.

9. Drops of dew on leaves acting as lenses focussing the sun's rays and heating small areas to the death point.

White rust, "frog eye," or "white speck" as it is variously known differs from brown rust in that the diseased areas are smaller and white in color. This rust occurs, occasionally, on nearly all tobaccos, but causes no great amount of damage. The spot was, in fact, formerly considered very desirable upon cigar wrappers, but upon the artificial production of a similar spot the natural white speck lost its value. Since the actual cause of the rust diseases are not known, no valuable means of control have been suggested. A wise precaution whenever practicable is to avoid planting tobacco in such fields or sections of fields where rust is known to occur repeatedly to an injurious extent.

THE MOSAIC DISEASE OR CALICO

This peculiar disease of tobacco is characterized by the mottled appearance of the leaf with light green and dark green areas, which in more pronounced cases results in the wrinkling or corrugation of the leaf. In severe cases the leaves may become so distorted as to be scarcely recognizable. Diseased leaves are as a rule, worthless for cigar purposes. Fortunately the disease has not occurred to a sufficient extent in Wisconsin to attract much attention, but its presence is frequently observed on suckers. The disease when it has once occurred in the fields, however, is capable of doing much damage to the growing crop and it is well for the growers to have in mind some measures which will aid in its control.

Several theories have been advanced as to the cause of this disease. The results of the more recent investigations upon this peculiar disease seems to show that it is not due to parasites, but to an abnormal condition of the living matter of the plant itself, which is capable of infecting and producing the disease in other plants.

Many interesting and practical points have been brought out as a result of investigations on this malady. The mosaic disease is of such a nature that it may crop out at any time in a field without previous infection, but is more liable to occur in fields where it has previously occurred. It has been well established that the causal matter may be liberated into the soil from decaying diseased plants and be taken up again by healthy plants to

a sufficient extent to cause disease. Anything, however, which tends to prevent the normal development of the plant may bring on the disease in any stage of its development. Usually, how-

FIGURE 6.—THE MOSAIC DISEASE OF TOBACCO.

This disease is characterized by a wrinkling or distortion of the leaf, with a loss of color in spots. Mosaic is contagious and may be transmitted from plant to plant in the process of topping and suckering.

ever, only the young growing parts of the plant are capable of becoming diseased. Any condition which favors the rapid growth of plants, such as excessive fertility or moisture in the

soil, favors the disease, and for this reason it is more likely to occur on clay than on sandy soils.

The following practical facts should be borne in mind:—

1. The seed-beds should not be started where the disease has once occurred unless the soil be previously sterilized by heat.

2. Diseased seedlings should not be transplanted into the field.

3 When the disease is liable to occur avoid planting on heavy or poorly drained soils, and the application of too much nitrogenous fertilizers.

4. When only a comparatively few diseased plants occur it is advisable to pull these out by the root and burn them.

5. Care should be taken not to allow the normal growth of the plants to be checked in any way.

6. The disease may be transmitted from one plant to another in topping and suckering. For this reason the person who is performing this operation on diseased plants should not work on healthy plants until the hands have been cleaned.

SHED BURN OR POLE ROT

The previously mentioned diseases of tobacco have been maladies affecting the living plant. We now come to the troubles of the grower and packer with the product after it has been harvested and is no longer in the living condition. The parasites which can develop upon the living tissues of any host are necessarily more or less limited. The saprophytes or organisms of decay which can develop upon dead material are much more numerous because of having usually a much wider range of substances from which they can obtain nourishment. Consequently we have a number of organisms capable of growing upon and decaying the tissues of the tobacco leaf, during curing, fermentation and storage, when favorable conditions for the development of these organisms exist.

Shed burn, or pole rot as it is frequently called, is recognized in mild cases by the development of small dark spots upon the curing leaf, and a resultant loss of elasticity of the affected parts which renders it valueless for wrapping purposes. These spots usually appear first near the veins or midribs, presumably because of more favorable moisture conditions at these points; later they may run together affecting the entire leaf which frequently falls apart almost from its own weight. In severe cases the entire contents of the curing house may be destroyed within

two or three days. Under practical conditions it is known to be brought about by too close hanging and poor ventilation associated with damp or foggy and warm weather. These conditions analyzed, simply mean a favorable amount of moisture, and a favorable temperature for decay surrounding the individual leaves. Ordinarily the disease does not occur until some days after the tobacco has been hung and has begun to change from greenish yellow to brown, indicating the death of the leaf tissue. Shed burn has been shown to be due to the development of fungi and possibly bacteria[1] upon the tissues of the leaf, resulting in the destruction of the texture of the leaf tissue. These organisms of decay are very commonly present in the soil, and upon the leaves when they are hung in the curing shed. No practical means for their eradication can be suggested and consequently the only means of control lies in preventing their growth by avoiding conditions favorable for their development in the curing shed.

Control of Shed Burn. Experience and experiments both have shown that the organisms which cause decay in curing tobacco can make very little or no growth at a temperature below 60 degrees or a relative humidity below 85 per cent. Since temperature and humidity are the controlling factors it is evident that anything which can be done to regulate these factors without interfering with the proper curing process of the leaf will satisfactorily tend to prevent or check the disease. Where "natural" curing is used, the process becomes almost wholly dependent upon weather conditions. Ventilation, to be sure, with properly constructed sheds and intelligent management, will go a long way towards preventing damage in the shed. If the weather conditions are very unfavorable at the critical stages of curing, however, no amount of ventilation can prevent damage. It is very important, therefore, in constructing a tobacco shed to bear in mind that it should be reasonably "tight" so that in damp weather, as much as possible of the moist atmosphere can be kept out. On the other hand, a good system of ventilators should be present so as to allow rapid reduction of the humidity of the interior of the shed when the weather becomes relatively dry. The up-

[1] According to Sturgis, in Connecticut shed burn is started by fungi, but the bacteria following are the main cause of the decay. In Wisconsin, a species of the fungus Fusarium appears to be the main causal organism.

to-date ventilating systems of tobacco sheds are composed of roof ventilators and horizontal ventilators between the tiers. When the roof ventilators and bottom ventilators are open under normal conditions, a current of air circulates from below upwards through the tobacco, carrying with it the excess moisture. This system will not work, however, during unfavorable weather conditions, necessitating a closing up of the shed to exclude the moisture, or resorting to artificial means of driving off the excess moisture. Since tobacco will not cure properly below 60 degrees and the temperature most favorable for curing, i. e., 80 to 100 degrees, is also favorable to the development of shed burn, it is evident that temperature regulation in itself, even though it were practical, would not be of much value. It is possible, however, to control the relative humidity to a large extent, by controlling the temperature and regulating ventilation. The amount of moisture that the air can hold varies greatly with the temperature. The ratio of the amount of moisture actually in the atmosphere at any time to the amount which can exist in the air at that temperature is known as the relative humidity. The capacity of the air for holding moisture is doubled for every increase of 18 to 20 degrees in temperature and the relative humidity is cut down by one-half. Consequently we find that under normal conditions as the temperature of the air in the shed increases in the day time, the relative humidity drops down below 80 per cent and frequently as low as 50 per cent. As the temperature falls at night, however, the relative humidity of the shed frequently reaches 95 per cent, which if maintained for many hours at a favorable temperature, would start decay. With the rise of the temperature the following day the humidity again drops below the danger point. During rainy or foggy weather the relative humidity remains high, and if the temperature is also relatively high, there is danger from the shed diseases. If now the temperature of the shed can be raised 15 to 20 degrees above that of the outside air and the air can be renewed by ventilation, the relative humidity can be dropped from near saturation to between 50 and 60 per cent, where no danger from the disease need be feared. If sufficient heat is not applied or is applied for too short a time, more harm than good may result, since a more favorable temperature for the growth of the fungi is produced, without reducing the humidity sufficiently to check their development. Where tobacco is cured by artificial heat, little or no damage

from decay occurs. When shed-burn has begun in a shed it is possible to check its development by the use of artificial heat.

This heat may be applied as open fires under the tobacco, or by means of furnace flues. On account of its cheapness and simplicity only the open fire method will be considered. The furnace flue system is rarely used except where curing is done by artificial heat alone. In order to obtain the best results from heating, the shed must be reasonably tight, and be supplied with good ventilators for use when desired. Material which gives dense smoke should not be burned in the shed as the quality of the leaf may be injured. Coal or coke cannot be used on account of the injurious gases. Charcoal, very dry wood, or corn cobs are best. Everything should be done to obtain as even heat as possible throughout the shed. For this reason a large number of small fires are preferable to a few large fires. The use of some sort of deflectors immediately above the flame to prevent the heat from going straight up is also desirable. The length of time fires are kept up will depend almost entirely upon weather conditions. Several small fires kept burning from 12 to 24 hours will usually be sufficient for all ordinary cases.

The Stem Rot Disease

In the curing process of tobacco the midrib, or stem, owing to its thickness, is the last to dry or cure out. When this process goes on normally the moisture given up by the tissues of the midrib passes off into the air as soon as it reaches the surface and the midrib remains relatively dry. If the humidity of the atmosphere is such, however, that it cannot readily take up more moisture the midrib becomes moist and soggy affording an opportunity for the spores of the fungi[1] which cause stem rot to germinate and grow into the stem causing its decay. It is of importance to the grower to know that these fungi are saprophytic or only very weakly parasitic and hence cannot attack living tissues. We again find therefore that the stem rot disease usually occurs to the most destructive extent some weeks after the tobacco is hung in the shed, and when the midribs are half cured out. The disease, therefore, usually comes on after the leaf is cured and the period of most danger from shed burn is past. These fungi

[1] Species of Fusarium, and *Tricothecium roseum* are the main causes of stem rot in Wisconsin. In Connecticut Sturgis reports *Botrytis longibrachiata* as the causal organism.

can only grow under favorable temperature and moisture conditions. So here again the remedy lies in regulating these factors as far as possible by artificial means when the general atmospheric conditions are such as to predispose the curing tobacco to disease. Hence the same principles of control may be applied as recommended for shed burn.

WET BUTTS OR FAT STEM

Wet butts is a wet, soggy and discolored condition of the midrib occurring during the curing process. The disease may also extend from the midrib into the veins of the leaf. The trouble is frequently to be found in Wisconsin tobacco where it occasions considerable loss. The writer is unacquainted with any scientific work upon the cause and remedy for this disease. Observations immediately suggests however that no parasite is connected with the disease. It appears to be a physiological trouble brought about by the freezing of the midrib before being properly cured out. This is borne out by the fact that it is the top leaves, the last to cure out, which are usually affected. Late tobacco is also especially subject to the disease. In stripping and sorting, the diseased leaves are separated out and allowed to dry out somewhat before being packed when they are placed in with the poorer grades of tobacco. When this trouble is likely to occur in the shed it is advisable to hasten the curing with artificial heat. Open fires for a day or two will very materially dry out the ribs before freezing weather. Late tobacco is always more likely to be damaged in the shed by this and other diseases. The production of an early crop of tobacco which allows at least a month to six weeks of warm curing weather in the fall is consequently one of the most important steps toward avoiding the shed diseases.

WHITE VEIN DISEASES

This disease rarely occurs in Wisconsin to a sufficient extent to cause much injury to the sale of tobacco. The disease is characterized by a whitened appearance of the veins making the leaf undesirable for cigar wrapper purposes. White veins are most probably of a physiological origin, coming on as they do after a long period of dry weather during curing. The appearance

is explained as being due to a more rapid drying of the outer cells of the veins permitting a thin layer of air to form between the epidermis (surface) and parenchyma (deeper) cells, hence causing the outer cells to appear white. If the relative humidity of the shed is kept up during dry weather by watering the ground in the shed it is possible to hold this trouble in check.

In certain Southern tobacco growing districts an insect (tobacco thrips) has been found to be parasitic upon tobacco, causing the appearance of white veins in the leaf. As far as determined this form of white veins does not occur in this state.

Black Rot in Sweating

The fermentation (sweating) of tobacco in cases is sometimes accompanied by the development of troubles which in the past have caused the packers considerable loss. Owing to the nature of the fermentative process it has been difficult to follow the development of the diseases, and the effect is not usually discovered until some time after the completion of the injury.

Black Rot is recognized by a dark brown or black color in place of the normal chocolate brown of a properly fermented leaf. The leaf maintains its form until mechanically disturbed when it is found to have lost its texture in spots. The disease is also recognized by the experienced packer by its odor which differs from that of ordinary fermenting leaves. The whole leaf is rarely affected, more commonly only small portions near the tips are diseased. The line of demarcation between rotted and unrotted areas is quite sharp, and sound portions are still of value if they are large enough to warrant their separation. Black rot has been found to be due to a fungus[1] which under favorable conditions of temperature and moisture grows and feeds upon the fermenting leaves in the interior of the fermenting piles. This fungus is peculiar in that it grows best at a high temperature (about 100 degrees) such as occurs in heating boxes of tobacco. For the control of black rot the packer should keep down the moisture content of the leaf to the minimum of that required for fermentation. To this end it is important that the growers should have the crop cured out before freezing weather sets in in the fall. This should be followed on their

[1] *Sterigmatocystis nigra* V. T.

part by taking down the crop for stripping before it comes into too "high case."

When packers obtain relatively moist tobacco (26 per cent

FIGURE 7.—TOBACCO LEAVES BADLY DAMAGED BY BLACK ROT

The control of black rot, which occurs during the sweating process, depends largely upon regulating the moisture content before packing, and controlling the temperature of the sweating process.

moisture and upward) it is possible to adopt one or more of the following courses to reduce the moisture before packing:—

1. Sort and pack the crops holding too much moisture late in the season after they have lost considerable moisture in the bundle,

2. Crops containing a high percentage of moisture may be bulk sweated with safety. The bulk sweating may be complete or only partial consisting of one or two bulkings before packing in cases.

3. The tobacco may be packed directly in cases and force sweated by raising the temperature of the tobacco above 113 degrees, which is above the temperature at which black rot will take place. Force sweating at 90 to 100 degrees may favor black rot.

4. If black rot is feared in tobacco packed early in the season, it is advisable to try to prevent fermentation by storing the cases in a cold room, unless they are to be force sweated. If the temperature in the interior of the case can be kept below 68–70 degrees until early summer when considerable moisture will have escaped from the leaves, the likelihood of black rot occurring during fermentation will be lessened. There appears however, to be some possibility of "must" occurring in relatively moist tobacco kept at a low temperature for some time.

5. It is possible that a drying machine or "evener" might be so constructed as to regulate the moisture content of all tobacco passed through it. By reducing the moisture in this way to 22-24 per cent the tobacco would be allowed to ferment properly, and danger from black rot would be reduced to a minimum.

MOLDS OR MUSTS

White mold or mustiness usually occurs to a greater or less extent upon fermenting tobacco. It does not appear to be associated with black rot in any way. The true molds are caused by fungi[1] developing upon the leaf in storage.

Since these troubles are caused by fungi it is evident that moisture is again a determining factor in controlling the disease. Practical observations indicate that when tobacco lies in cases for several weeks prior to a rise of temperature from fermentation, mold is very likely to occur. Reduction of moisture, as recommended for black rot, and force or bulk sweating will no doubt serve to control the disease in most cases. The occurrence of "must" seems to differ from that of black rot in

[1] Certain species of Penicillium, particularly *P. brevicaule* has been found upon mouldy tobacco in Wisconsin.

that relatively high temperatures are unfavorable to "must", though favorable to black rot. This explains why they usually do not occur together. Musty tobacco is frequently brushed to remove the color, but a characteristic odor remains which renders it undesirable. Some packers spray with water or with a four per cent acetic acid solution and repack.

A white salt appearing upon the midrib and veins of the curing and fermenting leaf produces a condition which is sometimes mistaken for white veins or mold. This condition is usually spoken of as "saltpeter" though some other salts are commonly found in conjunction with saltpeter. Saltpeter is of a less harmful nature than mold as it leaves no injurious odors and may be readily brushed off. It appears to be brought on by a sudden and rapid drying of the midrib and veins of the leaf, either during the curing or fermenting process, and conditions which bring on such rapid drying should be avoided as much as possible by the operator of the curing shed and packhouse.

A FEW MISCELLANEOUS DISEASES

In this country and abroad the tobacco plant is attacked by a number of other parasites most of which, however, are not known to occur in Wisconsin, or are only of minor importance. The tobacco wilt, broom rape, and mildew, fairly common diseases in other tobacco growing sections, do not occur as far as known in Wisconsin. Two diseases which have recently been observed and studied in a preliminary way in this state have been called "black leg" or "canker", and "hollow stalk". Blackleg or canker is characterized by the decay of the stalks of the plants in the field, at, and above the surface of the ground, rendering the plants weak at the base and readily blown over by the wind. In wet seasons the decay may spread toward the top of the plant, causing the stalk to blacken and the leaves to droop. This trouble appears to be caused by the same organisms which cause the damping off of seedlings in the plant beds[1]. It is possible that the trouble is caused in many cases by the transplanting of seedlings slightly affected with damping off. It is, therefore, advisable to avoid the transplanting of plants with brown or blackened spots upon their stems.

[1] See Wis. Exp. Sta. Research Bul. 31.

Hollow stalk is a decay of the pith of the stalk, sometimes extending out into the midrib and veins of the leaves causing them to droop. The decay may start from the base of the stalk, or at the top of the plant through injuries produced by topping or suckering. The disease has been shown to be apparently of a bacterial nature.[1] Diseased plants should be removed from the field when they occur in small numbers. Persons topping or suckering may carry the disease from diseased plants to healthy plants, which, if moist weather prevails, decay rapidly.

INSECTS OF TOBACCO*

The tobacco plant is attacked to an injurious extent by a large number of different kinds of insects. The majority of these pests, however, have not occurred in Wisconsin in dangerous numbers up to the present time, but may increase in the future. The insects which ordinarily cause the growers most concern in this state are the horn worms (tobacco worm), cutworms and grasshoppers. Of minor importance, in that they occur only rarely and do less damage, are the flea beetles, white grubs and wireworms. These insects are not limited to tobacco, but may occur upon a number of other plants, and particularly upon related plants, such as potatoes, tomatoes and jimson weed. Due perhaps largely to the more severe climate the insects of tobacco are not usually as abundant in kind or number in the Wisconsin growing sections as in southern tobacco districts. In certain seasons, however, the ravages of hornworms, cutworms and grasshoppers are sufficient to reduce the profits of individual growers one-half. In fact, the growers regard it as a very rare and fortunate season when one or the other of these pests do not reduce the profits or cause extra work and expense. This has resulted in increased interest from year to year, on the part of the growers in the matter of control measures which are applicable to their conditions. Very little has been done as yet in an experimental way on the control of tobacco insects in Wisconsin.

[1] A bacillus of the soft rot type has been isolated by the writer in pure culture, and the disease produced by inoculating healthy plants.

* The writer is indebted to J. G. Sanders, Entomologist of the Experiment Station for reading and approving the manuscript relative to insects.

Growers are frequently trying and suggesting old and new methods of control with more or less success. It is the purpose of this brief outline to bring together some of the more important of these methods of control, which have been practiced with the greatest success in this and other states.

THE PRINCIPLES OF CONTROL

The methods of control of any insect are based largely upon a knowledge of its life history, manner of feeding, habits and enemies. It is very desirable therefore that the grower learn something about the insect before applying the methods of control.

For the most part insects are peculiarly different from other forms of animal life in that they pass through different stages with very marked changes in form and manner of life. They can also be divided into two great classes in respect to this change in form, i. e., those which have a direct life history, and those which have an indirect life history. When the insect passes through four stages, i. e., egg, larva, pupa and adult, it is said to have an indirect life history, but if the insect develops from the egg to the adult by successive slight changes in form without the pupal stage, or resting stage as it is sometimes called, it is said to have a direct life history. The tobacco worm is a good example of an insect with an indirect life history while the grasshopper is an example of an insect with a direct life history.

The practical value in knowing the various stages in an insect's life lies largely in the fact that it enables the grower to combat the insect at its most vulnerable point. Some insects are quite uncontrollable in the stage in which they do injury, but are quite easily destroyed in other stages, and vice versa. All tobacco growers are acquainted with the fact that insects usually come in waves. In certain seasons they may appear in such numbers as to practically destroy a crop, and the following year may occur only rarely or not at all. This is due in a great measure to the natural enemies of the insects, especially unfavorable weather conditions, and the parasitism of other insects and diseases upon them. It is possible for man to aid nature in this destruction to a very considerable extent, particularly in exposing the wintering stages as much as possible by fall plowing of the land. Attempts have been made with success to artifically spread parasitic diseases and insects among certain injurious insects. The nearest

approach the tobacco grower has to that however, is to allow turkeys or guinea hens to roam about the tobacco fields and feed upon the tobacco worms and grass hoppers. Insects can sometimes be starved out in large numbers by keeping down their food supply whenever possible. This method is sometimes applicable in tobacco fields by means of crop rotation and in keeping down the tobacco plant suckers and weeds in the fall, which are feeding and breeding places for the insects.

The destruction of insects by poisoning is one of the most certain and satisfactory methods of control. This practice has been followed in several other tobacco growing states with good success, and should be practiced in Wisconsin when insects appear in such large numbers that they are very injurious. There are three principal ways of using poisons against tobacco insects, i. e. spraying the tobacco plant, spraying trap crops, and using a poisoned bait. For insects which obtain their food by chewing out portions of the leaves, arsenate of lead or Paris green may be applied to the leaves with a knapsack or compressed air sprayer, using it at the rate of about four pounds of arsenate of lead paste or four to six ounces of Paris green to one barrel (50 gallons) of water. Weeds, such as nightshade and jimson weed and the tobacco suckers, may be used as trap crops by spraying early in the season or late in the season when there is no tobacco in the neighborhood, with the idea of killing many insects which are congregated and feeding upon these related host plants. Poison baits are made by mixing a stomach poison such as Paris green with freshly cut clover or bran mash and scattering it about the fields for the insects to feed upon in the absence of other food. The methods of making these poison baits will be considered under the control of cut-worms.

The Hornworm or Tobacco Worm

Probably the most common, if not the most injurious insect pest of tobacco in Wisconsin is the horn or tobacco worm. Most growers are only acquainted with it as the light greenish, horned worm which infests the tobacco fields from July to September. These worms are heavy feeders and when they occur in great numbers they may frequently defoliate the plants. The adults of these worms are frequently seen in tobacco fields at dusk, as large, gray, strong,—flying moths. The moths lay small, greenish eggs, usually on the under side of tobacco leaves from which

hatch small larvæ or worms. The worms feed and grow upon the leaves until they become full grown, when they crawl into the ground to a depth usually of three to four inches. Here they form an earthern cell inside of which they go into the pupa or resting stage. The reddish brown pupae are frequently found in tobacco fields and are known as "pitchers" because of the resemblance of the long tongue case bent back over the body of the

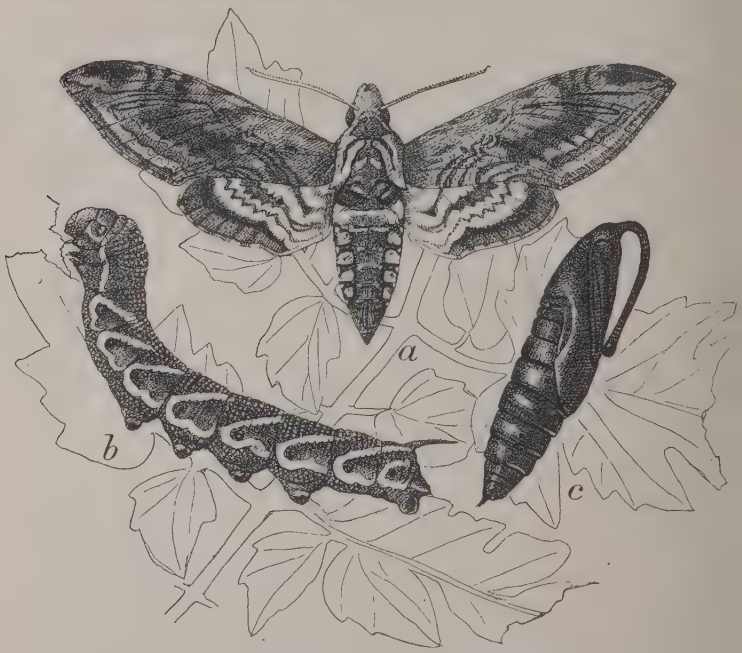

FIGURE 8.—THE NORTHERN TOBACCO WORM OR HORN WORM

a. Moth. *b.* Larva. *c.* Pupa, (after Howard). The tobacco worms appear in large numbers during certain years. Several methods may be practiced to control this pest.

pupa to the handle of a pitcher. Under favorable conditions the moths emerge from this resting stage after about three weeks, when they proceed to lay more eggs from which the second brood of worms develop. Many of the second brood of worms enter the ground and form an earthen cell again before freezing weather, and winter over in this stage.

Control. Shallow fall plowing will expose a large number of the pupae to sudden freezing and thawing which kills them. This,

together with the breaking up of the earthern cells with the plow and succeeding cultivation, will frequently serve as means of control.

When the worms occur only in small numbers they are frequently held in check by hand picking during topping and suckering. In seasons when they come in large numbers the growers sometimes resort to hand picking two or three times, when sufficient help is present, to save the crop. Flocks of turkeys and guinea hens in the fields sometimes serve to hold the insects in check, since they get the worms before they do much damage.

A more satisfactory method, however, in years when something must be done to check the worms or lose a large portion of the crop is spraying with arsenicals. For this purpose it is best to use arsenate of lead paste at the rate of about four or five pounds per 50 gallons of water. The cost of application should not be prohibitive as the poison can be bought at 15 to 20 cents a pound and cheaper in large quantities. One man with a knapsack or compressed air sprayer should be able to apply the mixture to about two acres of tobacco a day.

The Ordinary Cutworm

Cutworms are frequently a serious pest to tobacco as well as to a large number of other plants. The work of transplanting is sometimes doubled as a result of this insect feeding upon the newly set plants, besides causing a number of indirect losses therefrom. The insect more usually is injurious by cutting off the plant just at the surface of the ground, but sometimes climbs the stem of the plant and feeds upon the bud and young leaves.

The life history of the cutworm is similar to that of the hornworm in that it has an indirect life history. The adult is a medium sized, dingy colored moth which flys mostly at night and deposits its eggs usually upon the stems of plants. The larvae resulting from these eggs are grayish or brownish black worms measuring one to two inches in length. The worms feed during the night on any sort of green material with which they come in contact and hide in the soil or under debris during the day. When they are full grown they go into the resting stage in the ground to emerge later as moths. This insect may winter over either in the larval or pupal stage equally well, and for that reason is particularly troublesome early in the season.

Control. Cutworms are most likely to be injurious to tobacco or other cultivated crops when grown after sod or clover. For this reason special precautions should be taken when preparing sod or clover land for tobacco. Fall plowing should of course be practiced, being careful to cover up all vegetation. Many growers prefer late planting when cutworms are suspected to an injurious extent, and this precaution together with the poisoned baits are recommended for this purpose.

In using the poisoned bait it is necessary to first keep the field as clean as possible of weeds, two or three weeks preceding trans-

FIGURE 9.—THE TOBACCO CUTWORM

a. Adult. *b, c,* and *d.* Larvae. *e.* and *f.* Eggs, (after Howard). To decrease the extent of cutworm damage, careful attention to cultural practices is recommended to tobacco growers.

planting in order to reduce the food supply of the worms and render them hungry. A couple of days previous to transplanting spray a small patch of clover with Paris green at the rate of one ounce to six gallons of water. Cut the clover up into small bits and scatter in small handfuls about the field, preferably on a cloudy day and in the evening when the cutworms are out for food, and the clover will not dry out too rapidly. If these poisoned baits are not more than six to eight feet apart the hungry worms will have no trouble in finding them. In place of the poisoned clover bait, a poisoned bran mash bait may be used. This is made by mixing one pound of dry Paris green, with forty pounds of

bran. To this is added sweetened water, or a cheap syrup, stirring it thoroughly to get it all moist. This is scattered about the field in the same way as the clover bait and has the advantage in that it appears to attract the worms more than the clover bait. Poultry should be excluded from the treated area for some time, at least until the rain has washed the poison away.

Grasshopper Pests

Although grasshoppers are not ordinarily injurious to tobacco, they must be classed among the most injurious insect pests of tobacco in Wisconsin owing to the great losses they cause when they do appear. Grasshoppers do not usually attack tobacco when there is other food in the vicinity, but upon the reduction of other food crops by harvest or drought they migrate to the tobacco fields in great numbers.

The life history of the grasshopper is direct, omitting as it does the true resting stage. The female grasshopper lays its eggs in the fall especially in some spot covered with vegetation such as along fences and roadsides or on other uncultivated ground. These eggs hatch in the spring and the young grasshoppers emerge and feed upon the vegetation until they are full grown, when they again lay eggs for the following year.

Control. Grass lands and fence corners are constant breeding grounds for grasshoppers, therefore the tobacco fields should preferably be located as far away from these as possible. Wisconsin growers often separate grass plots from the tobacco fields by four or five rows of corn or sugar cane, which acts as a sort of break to the further spread of this pest and is no doubt a good practice.

Fall plowing, which either exposes the eggs to the weather or buries them so deeply that the young grasshoppers cannot reach the surface is a most desirable practice on land surrounding the tobacco field which is intended to be plowed and put into some cultivated crop. The grasshopper is subject to a number of natural enemies such as fungous diseases, other insects, birds, turkeys, and guinea hens, and these should be encouraged as much as possible. Trap crops, poisoned bait and spraying have also been suggested and tried to some extent as possible control measures. The writer has for a long time believed that spraying five or six rows around the edges of a field with Paris green or arsenate of lead would materially check the spread of the grasshoppers into

the field. No experimental proof of the value of this however, is at hand.

INSECTS OF MINOR IMPORTANCE

The insects which occasionally cause more or less damage to tobacco in Wisconsin are the flea beetles, grub worms and wireworms. Owing to their comparative unimportance in this state they will be mentioned but briefly.

The flea beetle is a small, active, dark brown insect which feeds upon tobacco and related plants, chewing small holes in the leaves in the field and in the plant beds. This insect is difficult to control in the field, but spraying is fairly satisfactory. In the plant beds they are readily controlled by spraying with arsenate of lead, using it at the rate of about 6 to 8 pounds to 50 gallons of water.

Wireworms are injurious to a number of crops, especially to corn and more rarely to tobacco. The worms burrow through the center of the young plant and cause it finally to wilt and die. These are among the most difficult insect pests to control. As precautionary measures one should avoid planting on sod known to be infested, and fall plow or summer fallow all sod before planting to corn or tobacco.

White grubs are the larvae of the "May beetle" or "June bug." As a result of their feeding upon roots in seasons when white grubs appear in the soil in large numbers they are noticeably injurious upon almost all types of plants. Nothing can be done to check their development on an extensive scale. Late fall plowing or summer fallowing is the best known means of holding them in check.

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